Space Weather Technical Forecast

Issued on Wednesday, 14 February 2024 at 01:26 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance G1 Minor Storms Day 1 (14 Feb) due to CME arrival. Ongoing chance of isolated M-flares, and slight chance X-flares. S1 Minor Radiation Storm easing.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low with peak flare C5.0 at 13/0759 UTC from a region over the northeast limb, and a number of other C-flares observed, primarily from AR3576 and AR3583. There are seven sunspot regions on the Earth-facing disc, the largest is AR3576 in the southwest. While this region lost some small trailer spots, growth was observed to the north and south of the main leader, with ongoing magnetic complexity and the persistence of weak delta spots. AR3583 showed little sign of development, persisting as a pair of closely located and small bipolar spots. AR3582 is the other main region on the disc, however this remained a stable region with a main leader-trailer east to west configuration and only small and weakening intermediate spots.

No Earth-directed CMEs were observed in available imagery.

Solar Wind / Geomagnetic Activity: Solar winds showed the arrival of a weak CME at 13/0140 UTC, likely a glancing arrival of the 10 Feb C-flare and filament eruption CME, which was anticipated to pass mainly to the south of Earth. Solar winds at L1 showed a small jump from 440km/s to 480-510km/s. These elevated winds gradually eased to 400-450km/s by 13/0730 UTC, and continued through 13 Feb. Density was at or near average levels. Interplanetary magnetic field (IMF) Bt, also showed a small jump at 13/0140 UTC, but only from very weak to weak values, rising from 3nT to 5-7nT, then persisted at this level. The north-south directed field, Bz, became mainly negative (southward) but was also weak, with minimum -6nT. Brief positive (northward) spells were observed with maximum +4nT. Phi angle was initially negative (towards the Sun) but became positive (away from the Sun) at 13/1330 UTC. Geomagnetic activity was mostly Quiet to Unsettled (Kp1-3), but with one Active (Kp4) interval 13/1500-1800 UTC.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux has was above the S1 Minor Radiation Storm through the period, and briefly rose above the S2 Moderate level for short spells between 13/0440 UTC and 13/0915UTC. However, this has since followed a sustained declining trend, falling to 20pfu at time of issue. Peak value in the last 24 hours was 118 pfu at 13/0610 UTC. GOES16 high energy (greater than 2MeV) electron flux remained at background. The associated 24-hour fluence was well below the Active (1e8 integrated pfu) threshold. The fluence at 14/0000UTC was 2.01e6 pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity is expected with the likelihood of isolated M-flares, and a slight chance of X-flares. These most likely from AR3576 in the southwest, or perhaps from a new region rotating onto the northeast limb.

Solar Wind / Geomagnetic Activity: There is one CME anticipated to arrive at Earth, originally forecast to arrive on 13 Feb, but perhaps arriving early on day 1 (14 Feb). This is from the M9 flare of AR3576 on 10 Feb. No other enhancements are expected, with solar winds likely easing to background once any CME influence eases. A spell of Active to G1 Minor Storm's is expected

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with the CME arrival, with a slight chance of G2 Moderate Storms. These could persist for much of day 1 (14 Feb). Otherwise mainly Quiet activity expected, with a decreasing chance of Unsettled intervals.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux is currently at the S1 Minor Radiation Storm, but on a declining trend, likely falling below this level later day 1 (14 Feb) but remaining above background throughout. Further enhancements are possible given any large flares, predominately from AR3576 which is moving into a favourable near west-limb location for causing observable proton evens at Earth. High energy electron flux (greater than 2MeV) is expected to be at background at first with a chance of rising to Moderate once any CME influence recedes. The associated 24-hour electron fluence is expected to stay below the active threshold, but perhaps with a rising trend later in the period.

Figure 1a AR3576 (top), AR3582 (middle) and AR583 (bottom) SDO hmi-intensitygram and magnetogram (left and right)

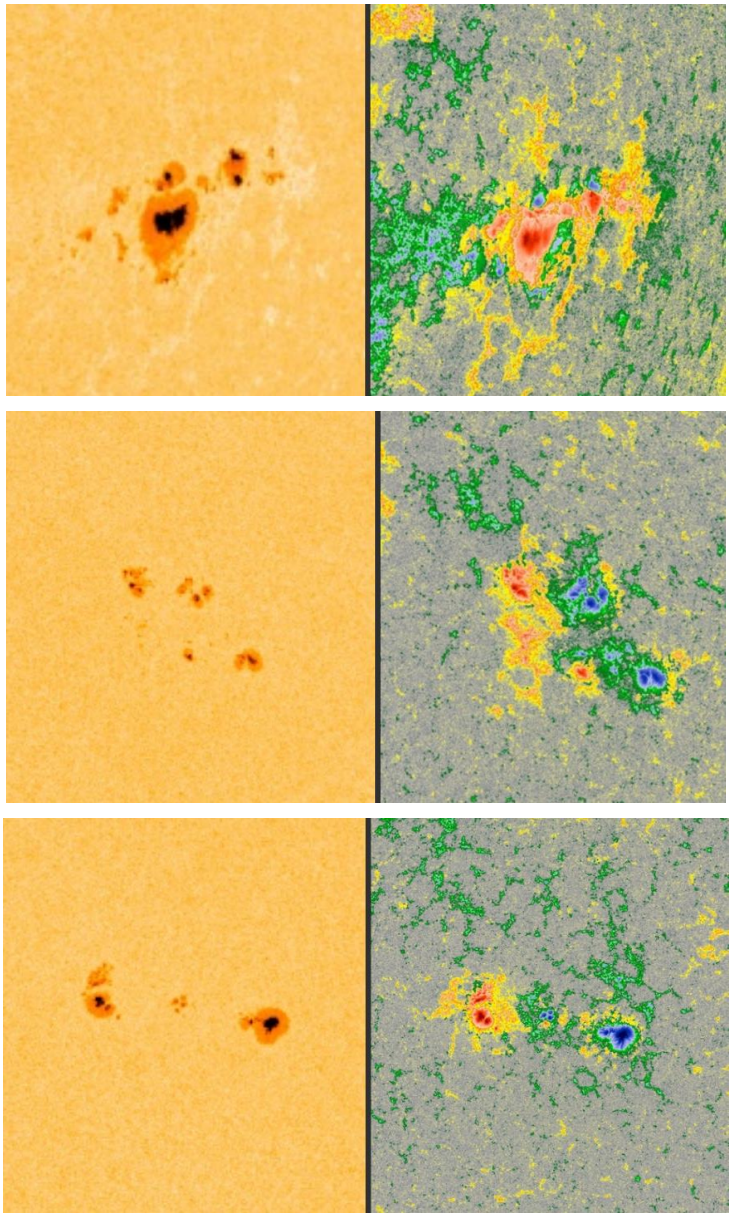

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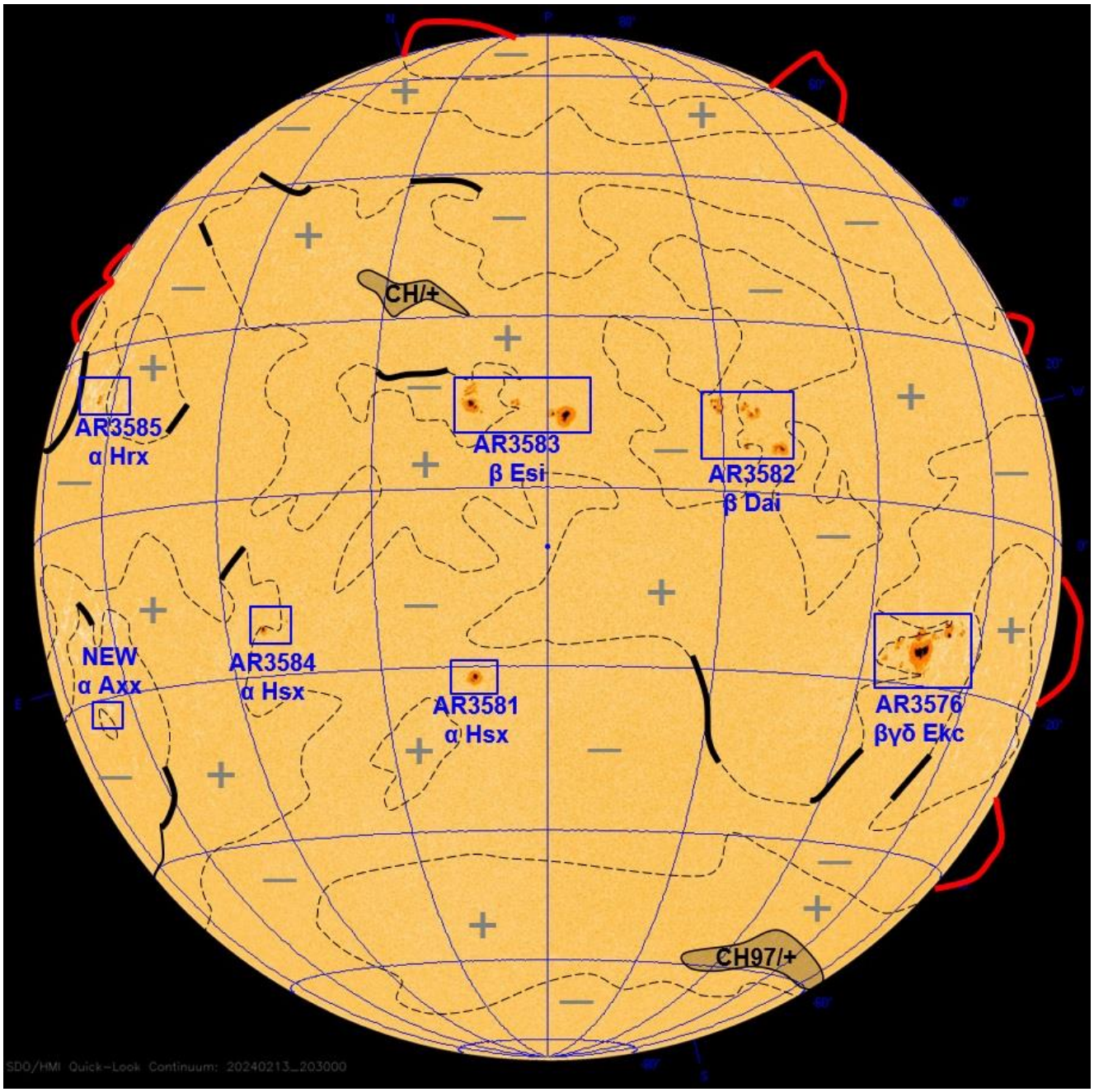
Figure 1b. Solar Analysis Valid 14/2030 UTC.



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Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There is one CME still anticipated to arrive at Earth, from the M9 flare of AR3576 on 10 Feb. This was originally expected on 13 Feb, but with a late arrival still possible on day 1 (14 Feb).

Solar winds are currently slightly elevated, although recent CME influence has now perhaps receded. In the absence of any CME arrival, this would be expected to ease to background day 1 (14 Feb), however any CME arrival may lead to winds persisting at around 450-550 km/s before easing to background day 2 (15 Feb). There are no coronal hole enhancements expected in the period, with coronal hole 97 too far south to influence solar wind at Earth.

A spell of Active to G1 Minor Storm's is expected with any CME arrival, with a slight chance of G2 Moderate Storms. These could persist for much of day 1 (14 Feb). Otherwise mainly Quiet activity expected, with a decreasing chance of Unsettled intervals.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	60	10	1	1
Strong	G3	No	5	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
11/0330	Partial halo shock. Material to NE	M9.0 AR3579 plus subsequent filament lift	S-centre, deflected NE	810 km/s	Early 14 Feb	Originally expected late 13 Feb, but not yet observed.

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Figure 2: MOSWOC Enlil

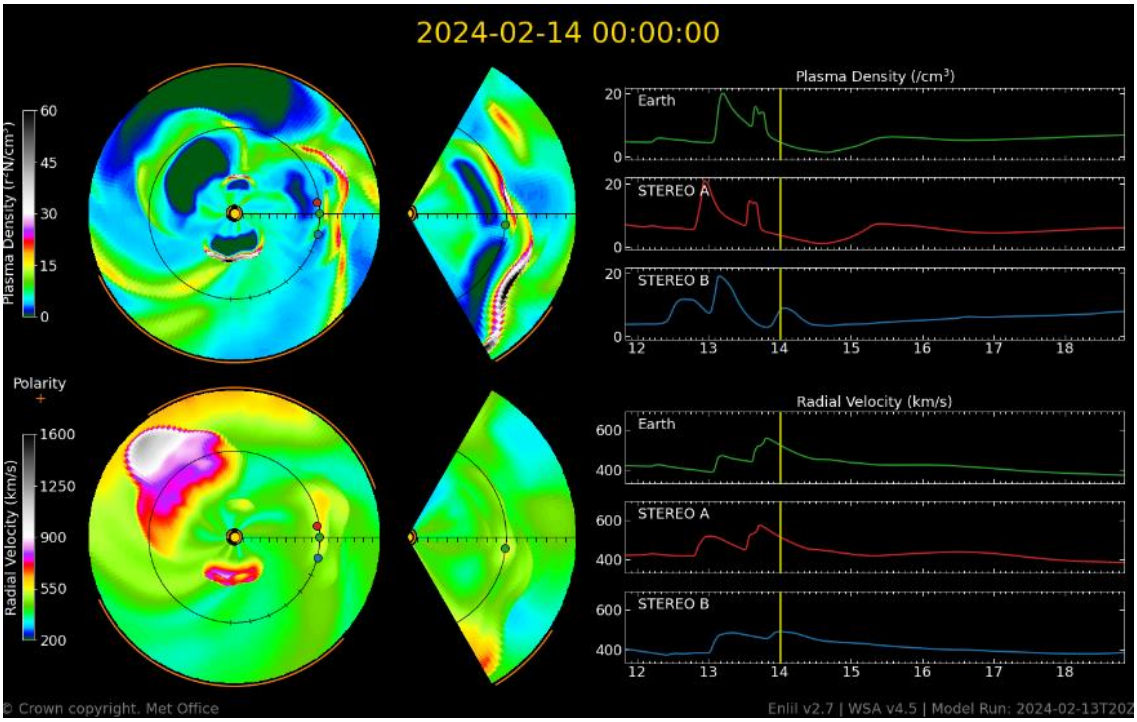
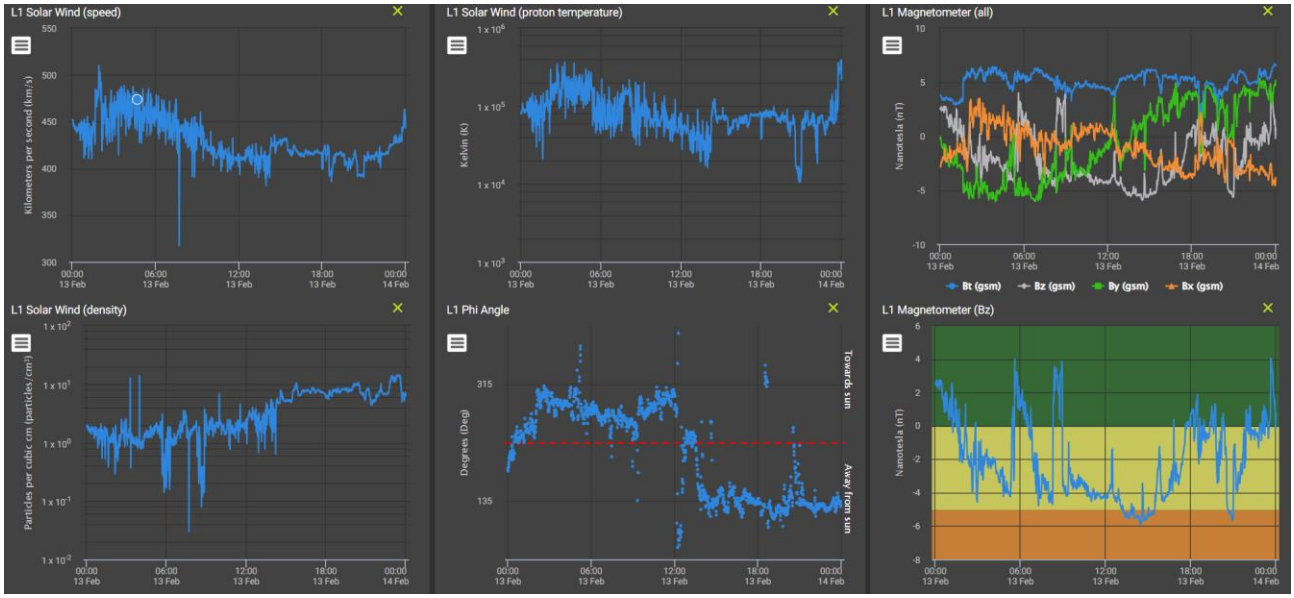


Figure 2b: Observed L1 winds on 13 Feb, showing weak, glancing CME arrival



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Radio Blackouts - X-Ray Flares:

Low to Moderate activity is expected with the ongoing likelihood of isolated M-flares. There remains a slight chance of X-class flares. These most likely from AR3576, the largest of the seven sunspots on the disc.

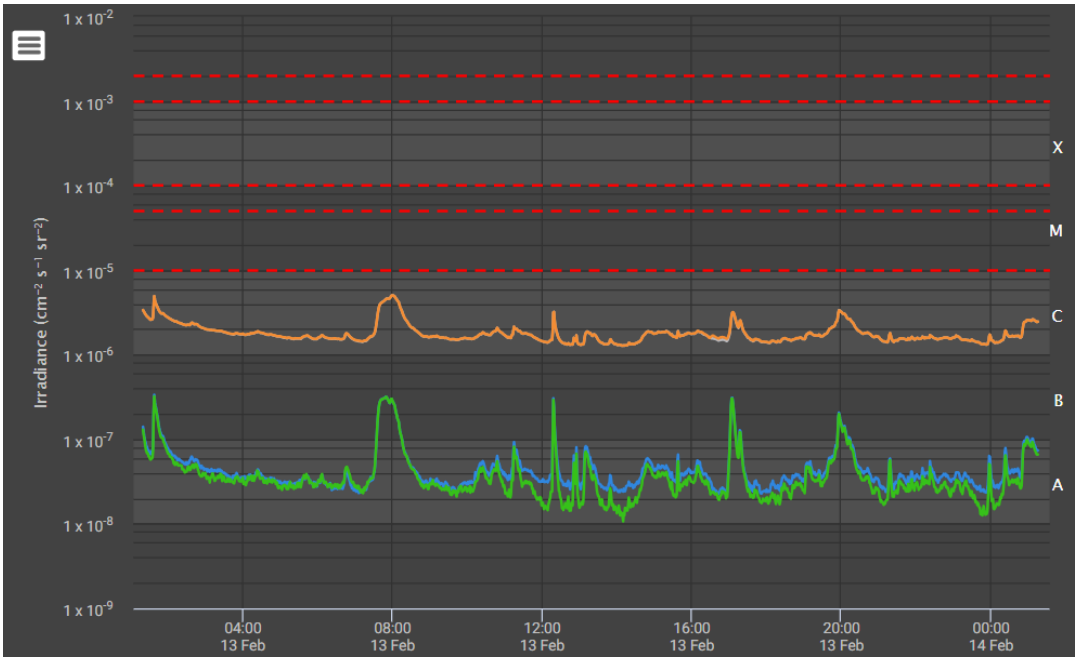
AR3576 has seen a recent reduction in spot numbers, but also some growth of positive polarity spots to the north and south of the main negative polarity leader. This includes the persistence of weak delta spots within the region, maintaining the complexity and consequently the potential for significant flares form the region. This region rotates over the west limb by day 4, however the flare risk from this region will likely continue until the end of the period.

AR3582 in the just west of the north-centre disc and AR3583 near the north-centre disc are also moderately sized regions, however these have a simpler magnetic configuration, and a horizontally aligned field, giving a lower potential for notable flares. Both these regions remain relatively stable with no growth observed.

Also of interest is a likely new region soon moving onto the northeast disc. This produced a LP M2.6 flare from over the limb on 12 Feb, with significant looping still visible on the limb.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	70	70	70	60
Very Active	R3 to R5 X Class	No	15	15	15	10

Figure 3: GOES 16-18 X-ray Flux



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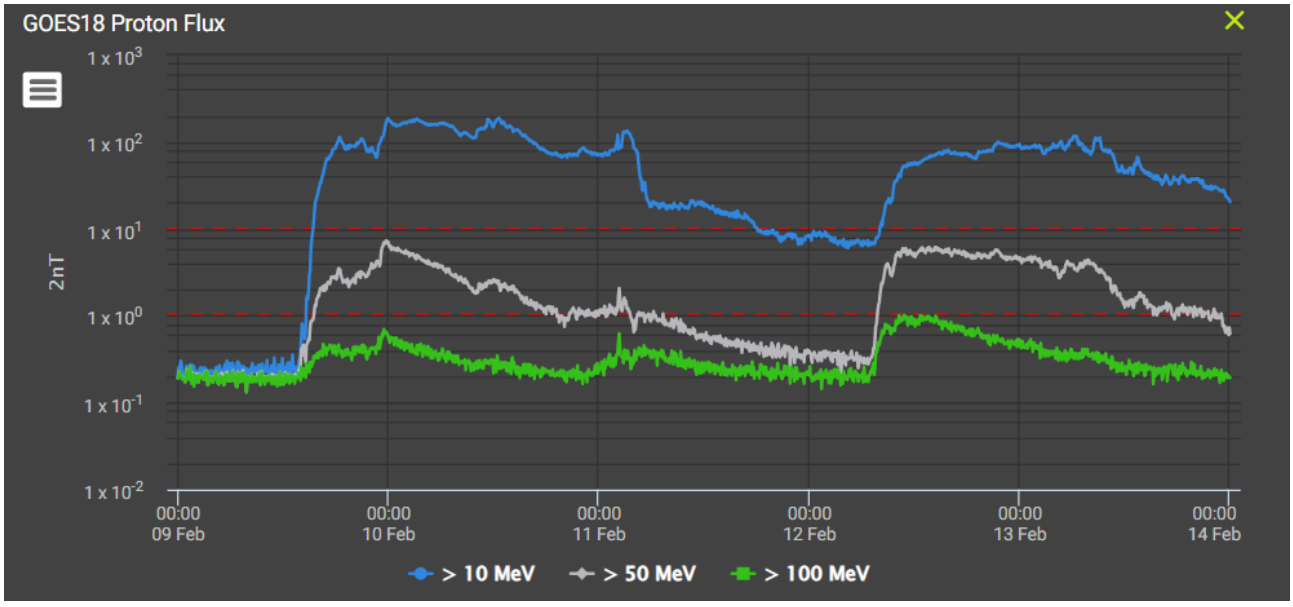
Solar Radiation Storms - (High Energy Protons):
GOES 18 high energy (greater than 10MeV) proton has been enhanced due to large far-sided flaring, most likely originating from AR3575 over the southwest limb. The most recent of these was observed with ejecta leaving the southwest limb on SDO imagery on 12 Feb. Observed proton flux rose to give an S2 Moderate Radiation storm, but has since declined to be at S1 Minor Radiation Storm levels. This is expected to continue declining through the period, likely falling below the S1 level by day 2 (14 Feb).
There is a slight chance of further enhancements, most likely from AR3576, given any significant flares, This is due its location in the western disc, which is favourable for any protons to be directed towards Earth.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	100	30	20	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES 18 Proton flux sine 09 Feb, showing periods of S1 and S2 Radiation Storms. These from the flaring of AR3575, now on the far-side.



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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) as observed by GOES-16 is forecast to persist at background, with the CME arrival on 12 Feb weak. Although this will depend on the strength of any enhancement from the expected CME arrival early on day 1 (14 Feb). A strong arrival could populate the Van Allen Belts, but also initially compressing them inside of GEO. As any enhancement eases, and these expand outwards again, flux could rise to Moderate with a very slight chance of peaking briefly at High from day 2 onward (15 Feb)

The associated 24 hour electron flux is expected to remain well below the Active (1e8 integrated pfu) threshold, but may see an increasing trend later in the period. REFM is giving good guidance in the absence of any further CME arrivals.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	1
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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